CONTRIBUTIONS ON PALAEOZOIC FLORAS. 2.

An Unusual Fossil Tree from Wollar, New South Wales.

By J. F. Rigby, Geology Department, Newcastle University College, Tighe's Hill, N.S.W.

(Five Text-figures.)

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Synopsis.

A small tree *in situ,* of Permian age, is described. Insufficient evidence is available to classify the tree, although there is some information regarding its habit (all growth of woody parts occurred in a vertical direction) and environment.

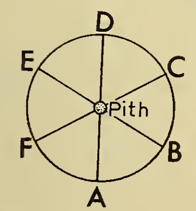
This fossil tree showed so many unusual features from the point of view of Permian trees that a preliminary note concerning it is of interest. It should be noted that little information of diagnostic value is available. Mr. R. Helby of the N.S.W. Mines Department found it, then kindly took me to the site and assisted in its collection. It was exposed by digging operations in the cutting at the western end of Wollar Tunnel on the Sandy Hollow to Gulgong railway formation, 80 miles WNW of Newcastle, New South Wales. It was preserved as a limonitic impregnation following silicification.

The tree was *in situ.* The lower axis (see Fig. 1) was vertical, but the upper axis had been broken and was lying at an angle of 30° to the horizontal pointing in a westerly direction.

The tree appeared to have lived under unfortunate conditions. Two ground levels formed during its growth. The lower 1′ 10″, termed the "lower axis" (see Fig. 1), was buried in a layer, now a blue-grey, fine-grained, argillaceous sandstone, then growth continued above the new ground level. A large bole developed at the second ground level. From this bole a second trunk grew, termed the "upper axis". The upper axis was knocked over and apparently killed during the deposition of a second bed of the same sandstone as the first deposit.

Table 1.

Radial Measurements to Edge of Bark, and to Prominent Growth Rings in Cross-section of Lower Axis of Permian Tree from Wollar, N.S.W. Measurements are in millimetres.
Diameter of pith: 25 mm.



Section line	A.	B.	C.	D.	E.	F.
Distance to edge of bark	40·8	39·0	30·2	28·8	27·3	35·6
Distance to prominent growth ring 1	3·1	3·2	3·0	2·1	2·0	2·9
Distance to prominent growth ring 2	8·0	8·1	9·3	—	—	8·1
Distance to prominent growth ring 3	24·9	31·6	23·8	20·5	19·6	31·0

Figure A.—Orientation of measured section lines listed in Table 1.

Roots developed below the first ground level. Unfortunately these were preserved only as carbonaceous ribbons up to 1 cm. wide. The root system was irregularly dichotomously branching. It occurred in the top few inches of the first ground level. No tap root, nor any structure similar to even a vestigial tap root, could be found. The root system seemed reminiscent of the system found in the Bambuseae, but to be rather sparse. The roots extended at least one foot from the trunk. No adventitious roots were found beneath the second ground level.

Litter occurred at both ground levels. The first ground level litter contained many recognizable leaves of *Glossopteris browniana* of all sizes, and fragments of *Phyllotheca australis*, both stems and leaves. Twigs were absent. Litter from the second ground level formed a structureless, very thin carbonaceous layer.

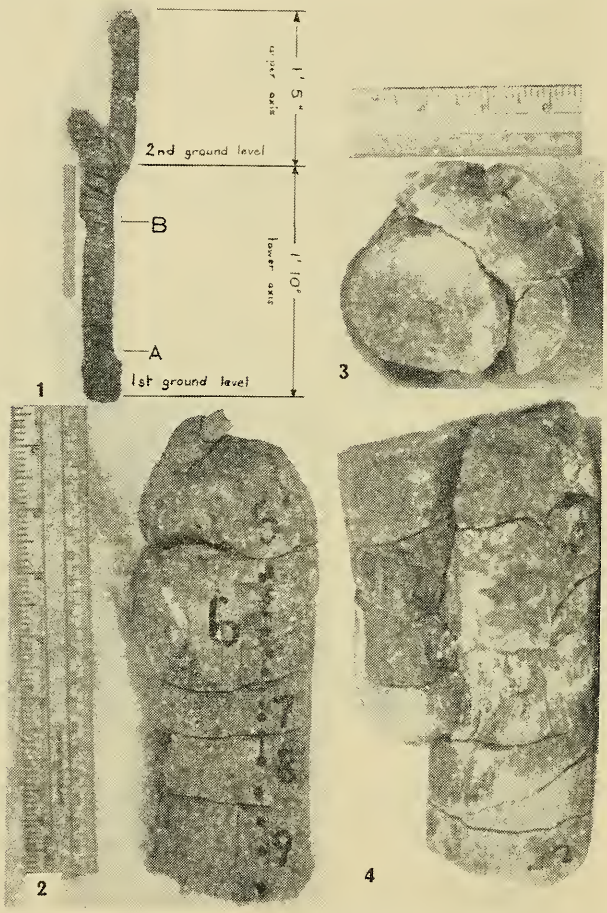


Fig. 1.—Fossil Tree from Wollar, N.S.W. Fragments of fossil reassembled into position of growth. Explanation as to the significance of the annotations is described in the text. Ruler is one foot long. × 1/18.

Fig. 2.—Detail of Fossil Tree from Wollar, N.S.W. Upper part of Upper Axis. Budding of branches may be seen as large, scale-like attachments. The numbers and dots were placed on the specimen to assist in reassembly in the laboratory. × ⅓.

Figs 3, 4.—Details of Fossil Tree from Wollar, N.S.W. Development of a new branch. 3, view from above of top of portion shown in Fig. 4 ; 4, side elevation. × ⅓.

The stem itself was endarch with a very narrow pith. The pith was generally eccentrically placed. In a cross-section at approximately half-way up the lower axis the measurements in Table 1 were made (all in mm.). Measurements were made along radial lines spaced at 60° from one another. Measurements were made to the edge of the bark and to prominent growth rings from the edge of the pith.

The section line A pointed towards the north. This eccentricity is not due to heliophyllism or to any tropism, as branching occurs on the side where growth had been a minimum. The unfortunate mode of preservation precluded detailed examination of the mechanism of branching. Where a branch occurred the pith did not appear to branch, but a new pith formed at the base of the new branch. All growth was entirely negatively geotropic, i.e., occurred in a vertical direction. The branch grew in contact with the main trunk, and in time replaced the original main trunk as the principal axis. Two such branchings may be seen clearly on Figure 1. One starts at B, and has become the main axis by the second ground level. Details of this branching are shown on Figures 3 and 4.

TABLE 2.

Showing Number of Cells and Width of Growth Rings of a Fossil Tree from Wollar, N.S.W. Measurements are in microns.

Growth Ring.	Width of Ring (in Microns).	Number of Cells across Width.	Cell Size. (Radial measurement given first.)
Pith (diameter)	2000 approx.	Cell size uniform	
	1710	71	12–33 × 12–29
1	1100	41	20–29 × 25–33
	At 60° to right of this section line this ring is subdivided by the insertion of two extra rings, viz.:		
	1720	25, 22, 24	
2	1160	49	As 1–2
3	975	51	20–41 × 29–41
4	1400	46	As 3–4
5	1880	60	
	Includes 4 minor rings spaced at 11/10/9/5/25		
6	1400	51	
7	580	24	
8	3050	87	
9	6000	156	
	Tendency for diagonal compression of the cells rather as if the bark were rotated slightly relative to the pith during growth		
10	3730	98	
	Insignificant growth ring		
	2280	76	
11	1010	28	
		Minor rings at 5/13/10	
12	650	26	
13	1040	28	
14	1290	37	
Cambium			
Bark, fibrous	2400–3200		

Other branchings are indistinctly visible on Figure 1. The main trunk of the lower axis grew from behind two other branches at ground level. The front branch appeared to be the main axis from which roots grew. This extended to slightly above the bottom of the ruler, as shown by eccentricity of the trunk, but has been preserved only as high as A.

The left arm at the second ground level appeared to consist of nothing but a very large mass of buds, or better, scales, of the type shown in Figure 2. A section cut through one of these scales showed that it was coherent with the parent stem throughout. Scale budding was frequent over the lower four inches of the upper axis and on and above fragment 6 (see Figure 2). The scale on the left of fragment 5 (from which it appeared to branch) would probably have developed into the main trunk, eventually superseding the main axis at that point as it was growing faster. The tip was hemispherical and ribbed.

As this tip was growing more rapidly than its parent trunk, it would develop a circular cross-section in preference to the trunk when both branch and trunk were in contact. This has happened to the trunk and branch shown by Figures 3 and 4.

The branching shown by Figures 3 and 4 emphasizes the way in which a branch assumes dominance during growth. The circular section in Figure 3 is of the branch.

The original trunk occupies the upper right portion of the section. The small lune-shaped portion, apparently part of the original trunk, shown in Figure 3 is a second branch that never assumed dominance. It appeared to branch at the level of the lowest remaining portion of the left hand branch. It appears out of focus on the front of the vertical section shown on Figure 4. Strong longitudinal ribbing is always found on both branch and trunk where they abut.

As growth was very slow, evident from the height of the tree, and the number of growth rings, the rate of photosynthesis must have been slow also. With such a plant one can only postulate a radiating crown of leaves as is found in modern cycads, and that these leaves were non-filicalean in nature. When budding or "scale formation" occurred at the apex, the available space for the attachment of leaves must have been severely reduced. The consequent reduction in photosynthetic activity might have accounted for narrower grower rings (see below).

Narrow medullary rays 4 to 5 cells in height appeared to occur sporadically. No thickening nor pitting of tracheids could be seen on any polished section, or transfer. Identification is impossible without these features. Tracheids were up to 50μ long. Radial air gaps were present in the secondary wood. They appeared to develop most often where the distance between growth rings was a maximum, i.e., where rate of growth had been a maximum whether or not growth rings indicated a seasonal growth.

Cell sizes and numbers of cells between each growth ring were measured on a transverse section cut in fragment 10 of the upper axis at the base of the part of the specimen shown in Figure 2. All measurements are in microns.

From these figures it is apparent that the factors controlling development of narrow, thicker-walled cells as growth rings were irregularly applied. The lower axis had 32 rings equally irregular in width, but with irregularities that bore no relationship to the irregularities in the upper axis. This would be consistent with cessation of growth of the lower axis at the time of the first flood, followed by commencement of growth of the upper axis.

It is quite possible that growth of the upper axis did not occur immediately, but that budding continued on the left-hand arm until a second inundation caused further damage. Following the second flood the present upper axis grew.

The size of growth rings may have reflected the quantity of water available, rather than the seasons, as the tree must have grown near a stream. This is shown by the presence of *Phyllotheca* in the litter. This is an alternative to reduction of growth owing to reduction in photosynthetic activity, or to normal seasonal cycles.

This tree can only be classified as a woody plant, hence seed bearing. It does not conform to the usual Cordaitalean pattern as it has a narrow pith. The only narrow pith endarch woods with homogeneous pith cells listed by Kräusel *et al.* (1962) from the Gondwanaland area are *Dadoxylon porosum* Kräusel and *D. rangei* Kräusel, both from South-west Africa. My tree may or may not be one of these. Final identification will depend on the finding of more suitable material.

I would like to thank Prof. Dr. R. Kräusel of Frankfurt a.M. for examining a small fragment of the wood, although he was not able to reach any conclusion as to its identity.

Reference

KRÄUSEL, R., MAITHY, P. K., and MAHESHWARI, HARI K., 1962.—Gymnospermous woods with primary structures from Gondwana Rocks—A Review. *Palaeobotanist,* 10: 97-107.

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